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ABSTRACT

The authors are in the process of interweaving mathematical ideas and the cultural contributions of the indigenous peoples of the Americas into what they teach. They are interested in how mathematics can be viewed culturally through the teaching of Indian Studies and Cross Cultural Education classes, how cultural components can be included in mathematics methods classes at the elementary level and in how specific examples of local cultures can be integrated into the teaching and learning of mathematics. Advancements in technology have made it possible for them to disseminate their ideas to preservice and inservice teachers through a Web resource called Math Central http://MathCentral.uregina.ca, the creation of an indigenous mathematics resource Web site http://education.uregina.ca/arnasonk, and an online mathematics course together with in-house published textbooks. This paper provides a context for the authors' work, describes a collaborative Transdisciplinary Project, and uses individual narratives to outline their explorations into the interweaving of mathematics and culture. (Author)

Interweaving Mathematics and Indigenous Cultures

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Abstract: The authors are in the process of interweaving mathematical ideas and the cultural contributions of the Indigenous peoples of the Americas into what they teach. They are interested in how mathematics can be viewed culturally through the teaching of Indian Studies and Cross Cultural Education classes, how cultural components can be included in mathematics methods classes at the elementary level and in how specific examples of local cultures can be integrated into the teaching and learning of mathematics. Advancements in technology have made it possible for them to disseminate their ideas to preservice and inservice teachers through a Web resource called Math Central <http://MathCentral.uregina.ca/>, the creation of an indigenous mathematics resource web-site <http://education.uregina.ca/arnasonk/>, and an online mathematics course together with in-house published textbooks. This paper provides a context for the authors' work, describes a collaborative Transdisciplinary Project, and uses individual narratives to outline their explorations into the interweaving of mathematics and culture.

Part 1: The Context of our Work

The four authors of this paper are faculty members at the University of Regina in Saskatchewan, Canada. Karen Arnason teaches Cross Cultural Education and Indian Studies for the Saskatchewan Urban Native Teacher Education Program (SUNTEP), Mhairi (Vi) Maeers teaches Mathematics Education and Technology Education for the Faculty of Education, and Judith McDonald and Harley Weston teach Mathematics for the Department of Mathematics and Statistics in the Faculty of Science. We are all presently collaborating on a Transdisciplinary Project to explore mathematics in a cultural context. Karen's focus is to present the numerous contributions of Aboriginal peoples (First Nation, Metis, and Inuit) to pre-service teachers in order that they incorporate culture in their teaching. She is also directing personal research practices in the area of Aboriginal Mathematics. Vi, who teaches mathematics methodology to preservice teachers specializing in Kindergarten through grade 8, has found it a challenge in her teaching to effectively present authentic examples of mathematics drawn from a historical/cultural perspective, or to ascribe to mathematics a specific cultural focus. Judi and Harley are involved in mathematics service classes for Education students through teaching, curriculum development, creation of in-house texts and the implementation of an on-line class. Harley maintains Math Central <http://MathCentral.uregina.ca/>, an Internet service for students, teachers, and mathematics users, developed jointly between Mathematics and Mathematics Education.

Part 2: The Project

In September of 2000 the Vice President Academic of the University of Regina, Katherine Heinrich, created a Transdisciplinary Project Fund to reflect and promote the multi-disciplinary character of understanding. We were awarded funding for a project entitled "Mathematics in a Cultural Context." The purpose of our project is to integrate First Nations, Inuit, and Metis cultural content into mathematics activities for use by preservice and inservice teachers. We have three major goals for this project:

1. to develop a resource for examining mathematical ideas in culture with a particular emphasis on the indigenous peoples of Saskatchewan. This will most likely include looking for mathematical ideas in art, games, stories, and cultural beliefs.
2. to develop a selection of story problems and examples which are culturally inclusive. This will also include an extensive bibliography of children's books that address cultural issues and mathematics.
3. to give access to this material to university students through its inclusion in mathematics content courses, in elementary preservice mathematics methods courses, in Cross Cultural and Indian Studies courses, and to teachers of the province through Math Central.

Part 3: Individual Narratives

Karen's Story

My role as an educator:

Many Indigenous students experience apprehension when it comes to mathematics, primarily due to past experience. For that reason, "I want to help my students learn to *read* (i.e., understand) the world -- through learning and using mathematics -- as a way for them to begin to *write* (i.e., change) the world", (Gutstein, 2001, 6).

Through the classes I teach for preservice teachers in the Saskatchewan Urban Native Teacher Education Program (SUNTEP) at the University of Regina, I will advocate mathematics as a significant and rich curriculum component.

The purpose of the ECCU 300 (Cross Cultural Education) class is to prepare pre-service teachers to explore the curriculum and incorporate Indigenous knowledge in their planning. Students enrolled in INST 101 (Indian Studies) will gain knowledge of Indigenous contributions in traditional and contemporary society in the areas of mathematics, science and technology, food, sports, medicine, arts, government, pathfinders, and world view. Both ECCU 300 and INST 101 present a multitude of contributions of Indigenous peoples

My role as a learner:

My interest in Indigenous contributions in mathematics has prompted the creation of a reading class towards my Masters Degree in Curriculum and Instruction. Dr. Mhairi (Vi) Maeers has been assisting me in the exploration of indigenous mathematics resources and the creation of a web-site <http://education.uregina.ca/amasonk/> that will be available for all educators. I have also compiled a collection of mathematics lesson plans, articles and resources organized by following the strands in Saskatchewan Education's Mathematics Curriculum Guide: Problem Solving, Data Management and Analysis, Number and Operations, Geometry and Measurement. In addition, I am producing a resource collection of teacher support materials, including string games, quilt patterns, finger weaving examples, children's books, and other mathematical associations.

My future role:

Through our collaborations I have discovered a fresh perspective of mathematics education where I can now "see" mathematics through a very different set of eyes, I am now able to recognize the mathematical ideas and concepts within the stories and everyday lives of Indigenous peoples, both historical and contemporary.

All that I have learned will enrich my teaching approach and instructional strategies, as well as direct the focus of my thesis research.

My personal belief is that when educators create a program that is relevant to learners, the propensity to learn is inevitable. Moreover, relevant content for Indigenous learners can potentially preserve a culture, promote self-identity, ensure pride and success, and increase motivation.

Vi's Story

For a long time I have considered mathematics to be an invention, created in the minds of people. People throughout history have played with natural materials in the environment, with ideas and have communicated these ideas to others. Gradually these ideas have been tested, duplicated, critically examined, and have become the big ideas of today's mathematics. All of mathematics has gone through a rigorous thorough examination to become the accepted forms that we take for granted today. New discoveries in mathematics travel this same road through rigour, peer

evaluation, to acceptance. The acceptance of the product of mathematical ideas focuses on finished or published knowledge and with its foundations and justifications.

However, there is also the activity of knowing or knowledge getting which is concerned "with the genesis of knowledge, and with the contribution of humans to its creation" (Ernest, 1991, 25). Mathematics, like any discipline is not static, but rather is evolving, is connected to other disciplines and is "indissolubly a part of the whole fabric of human knowledge . . . is an integral part of human culture, . . . (and is connected with) the rest of human knowledge through its historical and social origins" (26). When viewing mathematics we must "include external questions as to the historical origins and the social context of mathematics, in addition to internal questions concerning knowledge existence, and their justification" (26).

The products of mathematical knowledge and the processes of mathematical knowledge-getting have formed two distinct camps of mathematics philosophy and research (absolutist vs fallibilist). I personally have always viewed the process of mathematical knowing as an extremely important activity. In this present study I am again reminded of the importance of knowledge creation in its social/cultural/historical context and I feel constantly humbled by what I have often viewed as mathematics, and what has for me been an almost irrefutable 'truth' may not be viewed mathematically by others in the group. Also, some cultural artifacts may indeed be viewed mathematically by people from other cultures, but it may not be the same mathematics as I would attribute to the artifact. In our group meetings we are constantly discussing the mathematics labels—the mathematical names—we give concepts; other cultures may have different names for the same concepts.

Does the big debate on absolutism vs fallibilism in the philosophy of mathematics include all cultures or does it relate to a particular way of viewing the world—a particular ontology with a consequent set of epistemologies emerging from it. If a cultural group had a different ontology (and a different set of epistemologies) would that group perhaps have a different view of mathematics, a different way (s) of thinking mathematically, different origins of mathematics objects (e.g., numbers, functions, sets, etc), and different needs within the culture for using mathematics.

Karen and I are developing a mathematics education class that will focus on the mathematics of (some aspects) of culture and/or some cultural aspects of mathematics. The class might be called *Using Mathematics to Understand Culture and Using Culture to Understand Mathematics*. In this class we identify and explore the mathematics of cultural objects, discuss the issues that emerge for both mathematics and culture, link our work to the provincial curriculum, and develop a rich multi-media resource base for future work in mathematics and culture.

Judi and Harley's Story

Our main objective is to find ways to make mathematics accessible and appealing across a broader demographic spectrum. Through the transdisiciplinary project we have been focusing on ideas specific to the Indigenous peoples of Saskatchewan and the Americas. We are looking at both content issues—namely what we teach, and context issues—the settings we use for story problems and examples. We can implement the ideas we develop through two courses offered by the Department of Mathematics and Statistics to students in elementary and middle school education programs, and through Math Central. In the courses, and also through Math Central, teachers, whether inservice or preservice, are presented with mathematics content which is relevant to their teaching. Some of this content will influence the way they teach their students and will present them with activities and examples to use in the classroom. These two courses

will be taught from in-house published textbooks which we continue to develop and revise. One of the courses is currently offered by several regional colleges in the area, by the Saskatchewan Indian Federated College and on-line. Our hope is that through this transdisciplinary project we can develop mathematics content and contexts that contain some aspects of First Nations culture, history or experience in an appropriate and meaningful way and which teachers in our province can use with their students.

Below we illustrate three types of ideas, which we plan to use.
One of the courses contains a section on arithmetic and numeration systems. We plan to include material on the numeration systems developed by the Indigenous peoples of the Americas. For example, as part of the section on base arithmetic, we will work with the Mayan base 20 number system. In the history section we will introduce the quipu used by the Incas to represent numbers and illustrate the diversity that exists in the formation of number words among the First Nations languages.
As a second illustration, in the previous textbook for one of our courses, the probability section includes standard examples of games of chance using cards, dice, and coins. In our proposed in-house textbook we would like to include the following example adapted from *Games of the North American Indians* (Stewart, 1975).

Pahkasahkimca

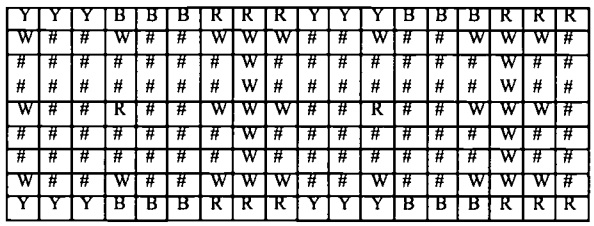
This is a Cree game that comes from the region of Coxby, Saskatchewan
The game is played with a set of 8 small bone objects, 4 in the shape of diamonds and 4 hook-shaped, and a wooden bowl or plate approximately 8 1/2 inches in diameter. The bone pieces are each approximately 3/4 inch long. Each piece is black on one side and white on the other.
The game is played by any number of people, either singly or in partnership. The bone pieces are placed in the bowl and tossed by giving the bowl a sharp downward movement with both hands. The count is then given by the following rules:

All white sides up	100 points
All dark sides up	80 points
7 white sides up and 1 dark side up	30 points
White sides of all hook-shaped and 1 diamond-shaped piece up	10 points
Dark side of all hook-shaped and 1 diamond-shaped piece up	8 points
White sides of 4 diamond-shaped and 1 hooked-shaped piece up	6 points
Dark sides of 4 diamond-shaped and 1 hook-shaped up	4 points
Any other outcome	0 points

(a) Find the probability of obtaining 100 points in one toss.
(b) Find the probability of obtaining exactly 10 points in one toss.
(c) Find the expected value of this game.

Thirdly we use beadwork as a context for illustrating modular arithmetic, ratio and proportion, and linear programming.

> The First Nations people of the Plains decorated clothing, bags, containers, quivers, and many other items. Beading was not only decorative, but symbolic and spiritual as well. For example, certain colours or shapes have symbolic meanings, but the beadwork could also have a personal meaning. Many of the patterns we see today are based on quillwork designs used before the introduction of glass beads (by European traders).



1. (Modular Arithmetic) Flora is designing a bead bracelet in the above pattern. The flower pattern repeats every eight beads. The border pattern repeats every nine beads.
   (a) If she needs the bracelet to be between 60 and 100 beads in length in order to fit her wrist, how many beads long should she make it so that the bracelet ends at a point where both patterns are complete?
   (b) How many times in the bracelet does the red center of a flower line up with a red bead on the border?
   (c) Make up your own bracelet design which has a middle pattern and border pattern which repeat at different lengths. Determine how long (number of beads) to make your bracelet in order to have the designs match at the ends.

2. (Ratio and Proportion) Flora is designing a bead bracelet in the above pattern. In the first problem she determined that the bracelet should be 72 beads in length. The flower pattern repeats every eight beads. The border pattern repeats every nine beads. Each flower pattern requires one red, 40 turquoise, and 15 white beads. Each border pattern requires three yellow, three blue, and three red beads. How many beads of each colour does she need to make the bracelet?

3. (Linear Programming) Flora makes bead bracelets and bead earrings. The bracelets sell for $6 each and each pair of earrings sells for $4. Each bracelet requires 400 blue beads and 80 white beads. Each pair of earrings requires 100 blue beads and 80 white beads. Flora has 6000 blue beads and 2400 white beads. How many bracelets and how many pairs of earrings should she make in order to generate the most revenue from the beads she has?

Part 4: Concluding Remarks

Much more is developing from this project than we had originally envisioned. We came together from various academic backgrounds and are being enriched in different ways. The project theme binds us together, while we weave the resulting threads into our own disciplines, implement our ideas in diverse ways, and grow ourselves from our interactions.

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